Biological and Species Interaction Survey of Pacific Hake, Sablefish, Spiny Dogfish and Pacific Herring off the Southwest Coast of Vancouver Island. *F/V EASTWARD HO.* August 10-22, 1985

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BIOLOGICAL AND SPECIES INTERACTION SURVEY OF PACIFIC HAKE, SABLEFISH, SPINY DOGFISH AND PACIFIC HERRING OFF THE SOUTHWEST COAST OF VANCOUVER ISLAND. F/V EASTWARD HO, AUGUST 10-22, 1985

by

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ABSTRACT

Shaw, W., R. Tanasichuk, D. M. Ware, D. Davenport, and G. A. McFarlane. 1987. Biological and species interaction survey of Pacific hake, sablefish, spiny dogfish and Pacific herring off the southwest coast of Vancouver Island. F/V EASTWARD HO, August 10-22, 1985. Can. Data Rep. Fish. Aquat. Sci. 651: 159 p.

A biological and species interaction study was conducted off the southwest coast of Vancouver Island (La Pérouse Bank) from August 10-22, 1985. Stomach samples from Pacific hake, sablefish and spiny dogfish were examined to evaluate the importance of Pacific herring as prey. Important dietary items (% volume) for Pacific hake were euphausiids (55%) and Pacific herring (40%); euphausiids (62%) and Pacific herring (15%) for sablefish; and euphausiids (89%) for spiny dogfish. Pacific herring were found in the stomachs of larger (>45 cm) Pacific hake and sablefish; and in dogfish >60 cm. Pacific herring in the stomach samples ranged from 15-28 cm. Lingcod were found to be feeding exclusively on Pacific herring.

Pacific hake ranged between 34 and 76 cm with modes at 49 and 52 cm for males and females, respectively. The sex ratio was dominated by females (62%). Five (1980 yr-class) and 8 yr-old fish (1977 yr-class) accounted for 27 and 32% respectively of the hake caught.

Sablefish ranged in size from 32-85 cm. Spiny dogfish caught in the midwater sets ranged in size from 44-86 cm and from 54-90 cm in bottom sets.

Pacific herring schools were concentrated on the southeast and mainly the southwest corners of La Pérouse Bank. Ages ranged from 1 to 10 with 3+ and 4+ accounting for 73% of the total catch. Length ranged from 16.9 to 24.3 cm (mode = 21.1 cm).

Key words: Pacific hake, sablefish, Pacific herring, species interaction, La Pérouse Bank

RESUME

Shaw, W., R. Tanasichuk, D. M. Ware, D. Davenport, and G. A. McFarlane. 1987. Biological and species interaction survey of Pacific hake, sablefish, spiny dogfish and Pacific herring off the southwest coast of Vancouver Island. F/V EASTWARD HO, August 10-22, 1985. Can. Data Rep. Fish. Aquat. Sci. 651: 159 p.

Du 10 au 22 août 1985, on a mené une étude sur la biologie et l'interaction interspécifique dans les eaux au large de la côte sud-ouest de l'île Vancouver (banc La Pérouse). Afin de déterminer l'importance du hareng du Pacifique comme proie, on a examiné des échantillons stomacaux de merlu du Pacifique, de morue charbonnière et d'aiguillat commun. Les plus importants aliments consommés (% volume) par chaque espèce sont les suivants: merlu du Pacifique - euphausiacés (55%) et hareng (40%), morue charbonnière - euphausiacés (62%) et hareng (15%) et aiguillat commun - euphausiacés (89%). On a observé du hareng dans les estomacs de gros merlus et de grosses morues charbonnières (>45 cm) et chez les aiguillats (>60 cm). La longueur du hareng consommé allait de 15 à 28 cm. On a aussi observé que la morue-lingue se nourrit exclusivement de hareng.

La longueur du merlu du Pacifique allait de 34 à 76 cm; les modes se situaient et 49 à 52 cm respectivement pour les mâles et les femelles. Les femelles (62%) dominaient la proportion relative des sexes. Les merlus de 5 ans (classe de 1980) et de 8 ans (classe de 1977) représentaient 27% et 32% respectivement des poissons capturés.

La longueur de la morue charbonnière allait de 32 à 85 cm tandis que la longueur des aiguillats communs capturés dans les traits effectués en eaux mésopélagique et benthique variait de 44 à 86 cm et de 54 à 90 cm respectivement.

Les bancs de hareng du Pacifique étaient concentrés à l'extrémité sud-est et surtout à l'extrémité sud-ouest du banc la Pérouse. L'âge du hareng allait de 1 à 10 ans et les poissons âgés de 3+ et de 4+ ans constituaient 73% des prises totales. La longueur allait de 16,9 à 24,3 cm (mode=21,1 cm).

Mots-clés: merlu du Pacifique, morue charbonnière, hareng du Pacifique, interaction interspécifique, banc la Pérouse

INTRODUCTION

In 1985, a study was initiated to determine the biotic and abiotic factors affecting year-class strength of commercially important species found off the southwest coast of Vancouver Island. One facet of this study was to determine the impact of Pacific hake (Merluccius productus), sablefish (Anoplopoma fimbria) and other groundfish stocks on Pacific herring (Clupea harengus pallasi).

This report contains the biological and oceanographic data obtained during the survey conducted from August 10-22, 1985.

MATERIALS AND METHODS

FISHING

The F/V EASTWARD HO was used for the entire survey. It is a 33 m (108 ft) commercial stern trawler powered by an 850 hp diesel engine. Fishing operations were conducted with two types of trawl gear. Midwater tows were made using a Diamond 8 midwater trawl equipped with an Elac model LAZ 17 headrope transducer. The codend mesh measured 8.8 cm (3.5 in) stretched mesh. Demersal tows were made using a "Rockhopper" bottom trawl with two 907 kg (2000 lb) doors. The codend mesh measured 8.8 cm (3.5 in) stretched mesh. Since neither net was equipped with a small mesh liner, small (age 0+, 1+, and 2+) herring were not fully represented in the catch. The herring catch reported in this report, therefore, are only representative of age 3+ and older herring.

Set locations for midwater trawling were selected on the basis of fish density in the midwater near Pacific herring schools as determined from echo sounder results. Bottom trawl sets were made on trawlable bottom near schools of Pacific herring.

BIOLOGICAL SAMPLING

The total weight of the catch from each tow was determined by estimating the quantity of fish in the codend. The weight by species was estimated by assigning percentage of the total catch to that species. Representative subsamples were collected from large catches using a six-tub subsample method (2 tubs each from the beginning, middle and end of the codend), while small catches were sampled in their entirety.

Pacific hake and sablefish were measured for fork length, sexed and examined for stomach contents. The procedure for sampling stomachs at sea was to select 10 stomachs per sex per centimetre interval and identify each prey item from each stomach to the lowest possible taxon and visually estimate their quantity (volume (cc)). Pacific hake were also examined for maturity state (Weir et al. 1978; McFarlane et al. 1982) and paired otoliths were collected for age determination as outlined in Beamish (1979). Spiny dogfish were measured for total length (tip of the snout to the tip of the upper lobe of the caudal fin when depressed in a line horizontal with the body), sexed and examined for stomach contents. Pacific herring were measured for standard length (tip of the snout to the hind margin of the hypural bone of the tail) and examined for stomach contents. Random samples of herring from selected tows were put into buckets, frozen and brought back to the laboratory. These fish were sampled for standard length, total weight, stomach contents and scales for age determination.

In addition to examining stomachs at sea, 100 full stomachs each from Pacific hake, sablefish and spiny dogfish were collected from each species-specific series of body length intervals. These stomachs were preserved in 10% buffered formalin for subsequent detailed analysis of prey items in the laboratory.

Incidental catches of lingcod (Ophiodon elongatus), Pacific cod (Gadus macrocephalus), bocaccio rockfish (Sebastes paucispinis), widow rockfish (Sebastes entomelas) and walleye pollock (Theragra chalcogramma) were measured for fork length, sexed and examined for stomach contents at sea. Full stomachs were also removed from lingcod, Pacific cod and bocaccio rockfish and preserved in 10% buffered formalin for subsequent laboratory analysis.

Pacific herring found in the stomachs of fish during the cursory examination onboard the vessel were counted and measured for standard length.

OCEANOGRAPHIC SAMPLING

Physical oceanographic data were collected at predetermined stations on three transects on La Pérouse Bank (Fig. 1). An STD-12 (applied microsystems) was used to measure the following properties and parameters of water selected at 2 m depth intervals: temperature, salinity, sigma-t, specific volume anomaly, dynamic height relative to the surface, potential energy relative to the surface and sound speed. All data were summarized by standard depths (0, 10, 20, 30, 50, 75, 100, 125, 150, 175, 200, 225, 250, 300, 400, 500 m).

A paired vertical plankton haul was completed at preselected stations using a modified Bongo sampler. Mesh size of both Bongo nets was 230 µm. Plankton samples, from one of the paired bongo nets, were preserved in 10% buffered formalin while the samples from the other net were frozen in plastic bags.

RESULTS

CRUISE SUMMARY

All physical oceanographic work and plankton sampling was conducted between August 11 and 13. STD casts were made at 30 stations (Table 1, Fig. 1). Vertical plankton tows (Fig. 1) were made at 11 of these stations. At one station (Set 29) a vertical plankton tow only, was made.

Trawling operations were conducted from August 13-21. Thirteen midwater tows (August 13-16) and 23 bottom tows (August 17-21) (Fig. 2) were completed. Detailed catch data by set is presented in Appendix Table 1.

In all, 31 species of fish were captured during the survey. A list of common and scientific names of the species caught is given in Table 2. The total catch by species during the survey was:

Species	Weight (kg)	% Total catch
Pacific hake	18247	65.8
Sablefish	3068	11.1
Spiny dogfish	2045	7.4
Arrowtooth flounder	1080	3.9
Redstripe rockfish	806	2.9
Lingcod	513	1.9
Bocaccio rockfish	367	1.3
Sharpchin rockfish	314	1.1
Other species[a]	1273	4.6
Total	27713	100.0

[a]Individual total weight for other species was <1% of the total catch.

Pacific hake and sablefish dominated midwater and bottom trawl catches respectively. The largest catch of Pacific hake (6770 kg) (Set 3) was made adjacent to the Finger Bank area at a midwater depth of 110 m. The largest catch of sablefish (1089 kg) (Set 19) was made on Finger Bank at a bottom depth of 102 m. Spiny dogfish were frequently encountered using both types of trawl gear. The largest catch of spiny dogfish (771 kg) (Set 28) was made on 40-mile Bank at a bottom depth of 64 m.

BIOLOGICAL SAMPLING

Pacific hake

Pacific hake were present in 85% of midwater sets and 35% of bottom sets. Biological samples were taken from 12 (33%) sets (10 from midwater sets and 2 from bottom sets). A total of 2057 hake were measured for length and sexed; otoliths were removed from 547 of these fish to determine age composition. An additional 252 fish obtained from stratified samples were used for stomach content analysis. A summary of the biological sampling is given in Table 3.

Female hake composed 62% of the total hake catch and dominated in 91% of the sets. The size composition of hake ranged from 34-76 cm (Appendix Table 2). Male hake ranged from 34-62 cm with a modal length of 49 cm, and females ranged from 38-76 cm with a modal length of 52 cm (Fig. 3). The majority (74%) ranged from 46-54 cm. Only 0.9% of the males and 6% of the females were $\geq$60 cm, similar to results in the 1983 survey by Shaw et al. (1985).

Pacific hake (Sets 3, 6 and 10) ranged from 2-18 years of age (Table 4). As noted by other workers (Beamish 1981, Beamish and McFarlane 1985 and Shaw et al. 1985), strong year-classes are an important component of this population. The dominant age groups were 5, 8, 12 and 15 yr (1980, 1977, 1973 and 1970 year-classes, respectively) (Fig. 4). Eight-year-old fish (1977 year-class) accounted for 32% of the hake sampled; five-year-olds (1980 year-class) were the second most abundant, accounting for 27% of the hake sampled.

A total of 257 males and 433 females were examined for maturity state (Table 5). Fifty-one percent of the males were in an early ripening (R_i) stage and 42% were in a resting (R_t) stage. Approximately 39% of the females were in an early ripening stage (R_i) with 61% in a resting stage (R_t), similar to previous results reported by Shaw et al. (1985).

A total of 692 hake were examined on board the vessel for stomach contents (Table 6). In addition, 113 full stomachs were preserved for later examination in the laboratory. Of the stomachs examined at sea 27% were either empty or everted. The principal prey (% by volume) identified in the stomachs containing food were euphausiids (Thysanoessa spinifera) (55%) and Pacific herring (40%). A total of 41 Pacific herring were identified in the stomach contents. In no case was more than one Pacific herring found per hake stomach. If those fish with empty and everted stomachs were ignored then approximately 8% of the hake contained Pacific herring. A total of 30 Pacific herring were measured for length and ranged in size from 15-28 cm ($\bar{x}$ = 20.0 cm; SD = 2.39).

The principal prey of small hake (<45 cm) (% by volume) were euphausiids (88%) and eulachons (12%). In the stomachs of hake ranging in

size from 45 to 60 cm, the principal prey were euphausiids (52%) and Pacific herring (42%). Again euphausiids (45%) and Pacific herring (42%) predominated as the principal prey for hake larger than 60 cm. The average volume of food per stomach (excluding empty or everted stomachs) was 3.4 cc for hake smaller than 45 cm; 14.5 cc for hake ranging from 45 to 60 cm; and 12.5 cc for hake larger than 60 cm.

Most of the Pacific herring were found in the stomachs of hake collected in midwater set 3 and most of the eulachons (Thaleichthys pacificus) and lanternfish (Myctophidae) were from stomachs of hake collected in midwater set 11.

Sablefish

Sablefish were encountered only in the bottom tows and were present in 61% of the sets. Biological samples were taken from sablefish captured in 15 (45%) sets. A total of 977 sablefish were measured for length and sexed. One hundred and sixty-five additional fish obtained from stratified samples were used for stomach content analysis. A summary of the biological sampling is provided in Table 7.

Males accounted for 61% of the total sablefish catch and dominated in 53% of the sets. The size composition of sablefish ranged from 32-85 cm (Appendix table 3). Males ranged from 32 to 73 cm and females from 34-85 cm (Fig. 5). Most of the smaller sablefish (32-42 cm) were caught near the Finger Bank area. These fish composed 23% of the total catch for all areas.

Stomachs from 827 sablefish were examined at sea (Table 8). In addition, 98 full stomachs were preserved for subsequent analysis in the laboratory. Of the stomachs examined at sea, 37% were empty. The principal prey (% by volume) identified in the stomachs containing food were euphausiids (62%) and Pacific herring (15%). Thirteen Pacific herring were identified with no more than one occurring per sablefish stomach. Excluding empty stomachs, approximately 3% of the sablefish contained Pacific herring. A total of 7 Pacific herring were measured for length and ranged in size from 16-22 cm ($\bar{x}$ = 18.6 cm; SD = 2.30).

The principal prey of smaller sablefish (<45 cm) (% by volume) was euphausiid (93%). In the stomachs of sablefish ranging in length from 45 to 60 cm, the principal prey were euphausiids (63%) and Pacific herring (18%). Sablefish larger than 60 cm contained, as the principal prey, euphausiids (45%) and unidentifiable fish remains (21%). In the latter size group, only one Pacific herring was found which accounted for 7% of the stomach contents by volume. Small barrel-shaped pelagic tunicates Doliolum spp. were only found in the larger sablefish (>60 cm) and accounted for 14% of the stomach contents by volume. Jellyfish remains were found in the stomachs of fish larger than 45 cm. Both tunicates and jellyfish remains accounted for 3% of the total volume, all of which were found in the stomachs of sablefish captured (sets 22-24) in the deeper waters south of La Pérouse Bank area. No Pacific herring were identified in the sablefish stomachs sampled from the same area (sets 20-25).

The average volume of food per sablefish (excluding empty or everted stomachs) was 2.8 cc for sablefish smaller than 45 cm; 8.1 cc for sablefish ranging from 45 to 60 cm; and 9.1 cc for sablefish larger than 60 cm.

Spiny dogfish

Spiny dogfish were present in 31% of midwater sets and 39% of bottom sets. Biological samples were taken from 13 (36%) sets of which 9 were from bottom tows. A total of 304 spiny dogfish were measured for length and sexed. An additional 238 fish were obtained from stratified samples for stomach content analysis only. A summary of the biological sampling is in Table 9.

Male dogfish accounted for 64% of the total dogfish catch and dominated in 85% of the sets. The size composition of dogfish caught in the midwater gear ranged from 44-86 cm; and 54-90 cm in the bottom gear (Appendix table 4). Juvenile dogfish $\leq$60 cm were more abundant in midwater catches (41%) than in bottom trawl catches (18%) (Fig. 6).

A total of 470 dogfish were examined for stomach contents at sea (Table 10); 22% of the stomachs were empty. An additional 71 stomachs were preserved for subsequent laboratory analysis. The principal prey (% volume) identified in the stomachs containing food was euphausiid (89%). Pacific hake and Pacific herring each accounted for 3% of the total volume. Four Pacific herring were identified in dogfish stomachs with no more than one herring per dogfish. Excluding empty stomachs, approximately 10% of the dogfish contained Pacific herring. A total of three Pacific herring were measured for length and ranged from 20-21 cm ($\bar{x}$ = 20.1 cm, SD = 0.58).

The principal prey of smaller dogfish (<60 cm) was euphausiid (70%). In the stomachs of dogfish ranging from 60 to 80 cm, the principal prey was again euphausiids (80%). Dogfish larger than 80 cm contained, as the principal prey, euphausiids (92%). Three of the four herring were found in the larger dogfish (>80 cm) and accounted for 3% of the stomach contents by volume.

Most of the Pacific herring were found in the stomachs of dogfish taken from bottom set 28 on 40-mile Bank.

Pacific herring

A summary of the biological samples taken is presented in Table 11.

Pacific herring were caught incidentally in one midwater haul (No. 2) and were targetted upon in three bottom hauls (Nos. 26, 27, and 28). During the survey high concentrations of herring were located at the southwest

corner, but especially on the 40-mile Bank within the 100 m edge (Fig. 1). Commercial trawlers targetting on lingcod on La Pérouse Bank in late July-early August reported seeing some of the biggest concentrations of large herring that they have seen in this area for at least 5 years (Nev Venables, pers. comm.). No signs of herring were seen either on the echograms or in the stomachs of sablefish along the 200 m edge. A few small herring schools were encountered while surveying the 100 m edge of Swiftsure Bank.

A total of 401 herring were measured for length and sexed. From 272 of these fish, stomach contents were examined and scales were collected. These data are summarized in Tables 12 to 17. The smallest herring sampled was 16.9 cm (age 1+) while the largest was 24.2 cm (age 6+). Most of the herring caught in the midwater and bottom trawl were ages 3+ and 4+ (73% of the sample). The youngest herring caught was age 1+ (16.9 cm), while the oldest was age 10+ (22.0 cm).

The principal prey of herring, as determined from the cursory examinations at sea and from laboratory analysis, was exclusively euphausiids. The number of fish containing food in each sample averaged 27% in set 2, 93% in set 26, 84% in set 27, and 80% in set 28. In the latter three sets, the stomach contents made up about 2% of the total body weight. The fullest stomachs occurred in the 17.0-19.0 cm size group in set 28, and averaged 6.7% of the body weight. By contrast, the stomach contents of the herring in set 2 averaged about 1.3% of the body weight.

Other species

A summary of the other species sampled is presented in Table 11. The length frequencies of lingcod, Pacific cod, widow rockfish, bocaccio rockfish and walleye pollock are presented in Appendix tables 5-9, respectively.

A total of 50 stomachs from lingcod were examined at sea of which 46% were empty (Table 18). Twenty-two additional full stomachs were preserved for subsequent analysis in the laboratory. The principal prey identified was Pacific herring (88% by volume). Thirteen Pacific herring were found in the stomachs of lingcod. The stomach capacity of lingcod was large enough to easily accommodate up to 3 relatively large Pacific herring. A total of 7 Pacific herring were measured for length and ranged from 19-24 cm ($\bar{x}$ = 20.9 cm; S.D. = 1.57).

Two stomachs from Pacific cod were examined at sea of which one was empty (Table 18). In addition 6 full stomachs were preserved for subsequent analysis in the laboratory. The principal prey identified was a flatfish spp. (Pleuronectidae), 38% by volume.

OCEANOGRAPHIC SAMPLING

Figures 7 through 11 summarize the station-specific oceanographic data presented in Appendix Table 10. Sea surface temperature distributions ranged from approximately 10 to 14°C over the study area (Fig. 7). Thermoclines generally occurred in the top 40 m. Temperatures below the thermocline varied less over the La Pérouse Bank area and were cooler on the Bank proper (Figs. 8 and 9). Sea surface salinity was lower near shore (Fig. 10). In contrast, salinity at depth (>50 m) alternated between low near shore, relatively high between La Pérouse Bank and the shelf break, then low beyond. Temperature and salinity at 200 m was uniform across sampling stations.

It is of interest that the large midwater catches of Pacific hake during the survey corresponded to temperature and salinity values of 6.5-7.1°C and 33.70-33.94°/$_{oo}$, respectively.

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REFERENCES

Beamish, R. J. 1979. Differences in the age of Pacific hake (Merluccius productus) using whole otoliths and sections of otoliths. J. Fish. Res. Board Can. 36: 141-151.

1981. A preliminary report of Pacific hake studies conducted off the west coast of Vancouver Island. Can. MS Rep. Fish. Aquat. Sci. 1610: 43 p.

Beamish, R. J. and G. A. McFarlane. 1985. Pacific Whiting, Merluccius productus, stocks off the West Coast of Vancouver Island, Canada. Mar. Fish. Rev. Vol. 47, No. 2: 75-81.

McFarlane, G. A., W. Shaw, J. M. Thompson, J. R. Scarsbrook, M. S. Smith, and K. L. Best. 1982. Data collected during hake and pollock assessments, Strait of Georgia cruises, February 20-May 2, and July 3, 1981. Can. Data Rep. Fish. Aquat. Sci. 339: 456 p.

Shaw, W., G. A. McFarlane, J. R. Scarsbrook, M. S. Smith, and W. T. Andrews. 1985. Distribution and biology of Pacific hake and walleye pollock off the west coast of Vancouver Island and the State of Washington. (August 15-September 5, 1983). Can. MS Rep. Fish. Aquat. Sci. 1825: 128 p.

Weir, K. R., R. J. Beamish, M. S. Smith, and J. R. Scarsbrook. 1978. Hake and pollock study, Strait of Georgia bottom trawl cruise G.B. REED February 25-March 13, 1975. Fish. Mar. Serv. Data Rep. 71: 53 p.

Table 1. Set locations for the STD casts and the vertical plankton hauls. F/V EASTWARD HO, August 10-22, 1985. (See footnote to Table 1 for cross reference of stn. number.)

Stn. no.	Type[a]	Position	Date	Time (PDT)	Depth of cast (m)
1	STD	48°39.00'N, 125°02.40'W	Aug 11	0645	50
2	"	48°35.67'N, 125°08.72'W	" 11	0735	100
3	"	48°32.18'N, 125°15.51'W	" 11	0833	100
4	"	48°25.30'N, 125°28.65'W	" 11	1215	146
5	"	48°18.57'N, 125°41.35'W	" 11	1350	150
6	"	48°12.92'N, 125°51.90'W	" 11	1600	450
7	"	48°10.60'N, 125°56.12'W	" 11	1637	480
8	"	48°48.68'N, 125°30.95'W	" 12	1230	110
9	"	48°46.95'N, 125°34.24'W	" 12	1210	155
10	"	48°43.43'N, 125°40.80'W	" 12	1145	145
11	"	48°39.94'N, 125°47.40'W	" 12	1030	65
12	STD/VH	48°36.46'N, 125°54.00'W	" 13	1110	90
13	STD	48°32.96'N, 126°00.56'W	" 13	1020	130
14	"	48°18.95'N, 126°26.70'W	" 13	0349	500
15	"	48°58.35'N, 125°47.05'W	" 12	1453	40
16	"	48°56.61'N, 125°50.40'W	" 12	1550	40
17	"	48°53.16'N, 125°57.00'W	" 12	1610	60
18	"	48°49.65'N, 126°03.60'W	" 12	1655	85
19	"	48°46.18'N, 126°10.20'W	" 12	1740	135
20	"	48°39.17'N, 126°23.40'W	" 12	1907	500
21	"	48°32.20'N, 126°36.60'W	" 12	2120	500
22	STD/VH	48°28.60'N, 126°08.10'W	" 13	0900	240
23	"	48°22.42'N, 126°04.12'W	" 13	0705	370
24	"	48°24.70'N, 126°15.80'W	" 13	0520	500
25	"	48°15.00'N, 126°40.00'W	" 13	0135	500
26	"	48°44.94'N, 125°22.00'W	" 12	0715	90
27	"	48°51.08'N, 125°39.20'W	" 12	1400	44
28	"	48°41.15'N, 125°27.05'W	" 12	0820	100
29[b]	VH	48°40.60'N, 125°46.25'W	" 12	-	90
30	STD/VH	48°29.00'N, 125°15.30'W	" 11	0915	150
31	"	48°23.45'N, 125°20.80'W	" 11	1050	123

[a]Vertical plankton hauls = VH.

[b]Stn. 29 was a vertical haul only.

Table 2. Common and scientific names of species captured during the F/V EASTWARD HO cruise, August 1985.

Common name	Scientific name
Pacific hake	Merluccius productus
Sablefish	Anoplopoma fimbria
Spiny dogfish	Squalus acanthias
Arrowtooth flounder	Atheresthes stomias
Dover sole	Microstomus pacificus
English sole	Parophrys vetulus
Pacific halibut	Hippoglossus stenolepis
Petrale sole	Eopsetta jordani
Rex sole	Glyptocephalus zachirus
Slender sole	Lyposetta exilis
Pacific ocean perch	Sebastes alutus
Redbanded rockfish	Sebastes babcocki
Silvergrey rockfish	Sebastes brevispinis
Darkblotched rockfish	Sebastes crameri
Greenstripe rockfish	Sebastes elongatus
Widow rockfish	Sebastes entomelas
Yellowtail rockfish	Sebastes flavidus
Rosethorn rockfish	Sebastes helvomaculatus
Bocaccio rockfish	Sebastes paucispinis
Canary rockfish	Sebastes pinniger
Redstripe rockfish	Sebastes proriger
Yellowmouth rockfish	Sebastes reedi
Yelloweye rockfish	Sebastes ruberrimus
Sharpchin rockfish	Sebastes zacentrus
Chinook salmon	Oncorhynchus tshawytscha
Eulachon	Thaleichthys pacificus
Lingcod	Ophiodon elongatus
Pacific cod	Gadus macrocephalus
Pacific herring	Clupea harengus pallasi
Walleye pollock	Theragra chalcogramma
Ratfish	Hydrolagus colliei

Table 3. Summary of Pacific hake sampled. F/V EASTWARD HO, August 10-22, 1985.

Set[a] no.	Average net depth (m)	Length M	Length F	Length T	Maturity	Paired otoliths	Stomachs examined	Stomachs preserved	Remarks
2	91	86	165	251	124	190	190	25	Random 6/6 tubs
3	110	42	125	167	101	168	20	10	Random 4/6 tubs
		6	42	48			36	12	Stratified 1 tub
4	-	77	144	221					Random 4/6 tubs
		8	44	52			46	6	Stratified 1 tub
5	110	64	125	189					Random 4/6 tubs
		14	37	51			26	25	Stratified 1 tub
6	91	68	148	216	180	180	17	3	Random 5/5 tubs
		5	35	40			31	9	Stratified 1 tub
7	91	4	32	36			28	7	Random 1 tub
9	128	134	167	301	104		41	4	Random 5/6 tubs
10	123	151	156	307	181	199	1		Random 5/6 tubs
		24	24	48			43	5	Stratified 2/2 tubs
11	146	99	98	197			196	1	Random 5/5 tubs
12	-	61	101	162					Random 2/3 tubs
		0	2	2			1	1	Stratified
18	95	0	11	11			6	5	Stratified
29	126	0	10	10			10	-	Total catch
Total (non-(stratified)		786	1271	2057	690	547	503	50	
Total (stratified)				252			189	63	

[a]Sets 2-12 are midwater trawl samples; Sets 18-29 are bottom trawl samples.

Table 4. Mean size (cm) at age of Pacific hake for each age class from Sets 3, 6 and 10. F/V EASTWARD HO, August 10-22, 1985.

	Male			Female			Total		
Age (yr)	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N	$\bar{X}$	S.D.	N
2	-	-	-	38.0	0.00	1	38.0	0.00	1
3	48.0	0.00	1	0	0	0	48.0	0.00	1
4	45.4	2.47	15	46.2	3.50	25	45.9	3.14	40
5	47.0	2.86	47	48.6	3.01	84	48.0	3.05	131
6	48.8	2.32	16	51.0	2.32	11	49.7	2.54	27
7	49.3	2.58	20	52.6	2.77	33	51.3	3.12	53
8	49.8	2.16	55	53.1	3.20	102	52.0	3.28	157
9	50.8	2.49	5	53.0	1.00	3	51.6	2.26	8
10	51.3	2.87	4	55.6	6.19	5	53.7	5.24	9
11	51.5	1.91	4	56.2	4.63	5	54.1	4.83	9
12	54.8	3.24	12	54.9	2.85	15	54.9	2.97	27
13	49.5	3.54	2	55.5	3.70	4	53.5	4.51	6
14	0	0	0	0	0	0	0	0	0
15	51.5	0.58	4	56.1	3.31	19	55.3	3.50	23
16	-	-	-	59.0	0.00	1	59.0	0.00	1
17	-	-	-	59.0	0.00	1	59.0	0.00	1
18	-	-	-	62.0	0.00	1	62.0	0.00	1
Total			185			310			495

Table 5. Pacific hake maturity frequency. F/V EASTWARD HO, August 10-22, 1985.

Set no.	2			3			6			9			10			Total		
Gonad maturity stage	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T	M	F	T
R1	25	5	30	12	1	13	36	73	109	26	41	67	50	48	98	149	168	317
R2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rb	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	2	2
Rc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rt	14	78	92	15	73	88	20	51	71	15	21	36	43	40	83	107	263	370
Total	40	84	124	27	74	101	56	124	180	41	63	104	93	88	181	257	433	690

Table 6. Pacific hake stomach contents. F/V EASTWARD HO, August 10-22, 1985.

	Size category			
	<45 cm	45-60 cm	>60 cm	Total
Number examined	94	539	59	692
Number everted	8	91	3	102
Number empty	13	18	13	44
Number with contents	73	430	43	546
Diet - volume (cc)	(cc)	(cc)	(cc)	(cc)
Pacific herring	-	2595 (36)[a]	223 (5)[a]	2818 (41)[a]
Eulachon	31	215	30	276
Pleuronectidae	-	80	-	80
Leuroglossus	-	68	5	73
Fish remains (unid.)	-	1	30	31
Myctophidae	-	13	-	13
Euphausiid	218	3230	241	3689
Pink shrimp	-	37	7	44
Squid (spp.)	-	2	-	2
Total	249	6241	536	7026

[a]Brackets indicate total number of herring in the stomachs of hake of which 30 were deemed measurable. Measurable herring are as follows: 2 @ 15, 16, 17, 18; 5 @ 19; 7 @ 20; 8 @21; 4 @ 22, and 28 cm).

Table 7. Summary of sablefish sampled. F/V EASTWARD HO, August 10-22, 1985.

Set[a] no.	Average net depth (m)	Length			Stomachs examined	Stomachs preserved	Remarks
		M	F	T			
15	66	1	7	8	6	2	Total catch
16	95	33	29	62	50	12	Total catch
17	101	71	56	127	113	12	Total catch
18	95	263	216	479	356	35	Total catch
19	102	57	60	117	107	10	Stratified
20	159	8	13	21	16	5	Total catch
21	152	177	42	219	99	4	Total catch
22	196	32	11	43	27	7	Total catch
23	190	8	4	12	9	1	Total catch
24	203	2	2	4	2	2	Total catch
25	157	18	13	31	29	2	Stratified
26	82	1	1	2	-	2	Total catch
27	71	2	0	2	1	1	Stratified
28	64	1	6	7	4	3	Stratified
29	126	3	5	8	8	-	Stratified
Total (non-stratified)		596	381	977	678	82	
Total (stratified)				165	149	16	

[a]All sets are from bottom trawl

Table 8. Sablefish stomach contents. F/V EASTWARD HO, August 10-22, 1985.

	Size category			
	<45 cm	45-60 cm	>60 cm	Total
Number examined	247	399	181	827
Number empty	136	64	101	301
Number with contents	111	335	80	526
Diet - volume (cc)	(cc)	(cc)	(cc)	(cc)
Pacific herring	-	503(12)[a]	50 (1)[a]	553 (13)[a]
Fish remains (unid.)	15	185	150	350
Pacific hake	-	232	26	258
Spiny dogfish	-	-	47	47
Salmonidae	-	15	-	15
Myctophidae	-	3	-	3
Euphausiid	285	1715	331	2331
Sipunculid	-	30	-	30
Pink shrimp	3	10	4	17
Sea mouse	-	8	-	8
Amphipod	1	-	1	2
Crab remains	2	-	-	2
Polycheate (spp.)	-	1	-	1
Snail (spp.)	-	-	1	1
Tunicates	-	-	105	105
Jellyfish remains	-	6	6	12
Pebbles	-	11	2	13
Green algae remains	-	2	7	9
Total	306	2721	730	3757

[a]Brackets indicate total number of herring in the stomachs of sablefish of which 7 were deemed measurable. Measurable herring are as follows: 2 @ 16, 17, 19; 2 @ 20, and 28 cm).

Table 9. Summary of spiny dogfish sampled. F/V EASTWARD HO, August 10-22, 1985.

Set[a] no.	Average net depth (m)	Length			Stomachs examined	Stomachs preserved	Remarks
		M	F	T			
4	-	33	31	64	61	3	Random 2/2 tubs
5	110	19	12	31	31	-	Random 2/2 tubs
6	91	8	9	17	16	1	Total catch
7	91	44	32	76	64	11	Random 2/2 tubs
15	66	24	23	47	47	-	Stratified
17	101	9	1	10	9	1	Total catch
20	159	7	0	7	5	2	Total catch
26	82	14	1	15	10	5	Total catch
27	71	13	0	13	11	2	Total catch
28	64	170	10	180	138	42	Stratified
29	126	3	0	3	3	-	Total catch
30	97	4	7	11	11	-	Stratified
36	121	43	25	68	64	4	Total catch
Total (non-stratified)		193	111	304	274	29	
Total (stratified)				238	196	42	

[a]Sets 4-7 are from midwater trawl; sets 15-36 are from bottom trawl.

Table 10. Spiny dogfish stomach contents. F/V EASTWARD HO, August 10-22, 1985.

	Size category			
	<60 cm	60-80 cm	>80 cm	Total
Number examined	85	249	136	470
Number empty	19	73	13	105
Number with contents	66	176	123	365
Diet - volume (cc)	(cc)	(cc)	(cc)	(cc)
Pacific hake	46	123	151	320
Pacific herring	-	60 (1)[a]	225 (3)[a]	285 (4)[a]
Fish remains (unid.)	-	162	87	249
Turbot	-	80	-	80
Agonidae	-	-	50	50
Salmonidae	-	-	50	50
Pacific saury	-	-	40	40
Pleuronectidae	-	15	-	15
Eulachon	-	10	-	10
Myctophidae	-	5	-	5
Euphausiid	112	1935	6999	9046
Pink shrimp	1	23	-	24
Invert remains (unid.)	-	5	-	5
Crab (spp.)	-	-	2	2
Snail (spp.)	-	1	-	1
Pebbles	-	10	-	10
Total	159	2429	7604	10192

[a]Brackets indicate total number of herring in the stomachs of dogfish of which 3 were deemed measurable. Measurable herring are as follows: 2 @ 20, and 21 cm).

Table 11. Summary of other species sampled. F/V EASTWARD HO, August 10-22, 1985.

Set no.	Length M	Length F	Length T	Stomachs examined	Stomachs preserved	Remarks
			Lingcod			
18	-	1	1	1	-	Total catch
22	-	1	1	1	-	Total catch
24	-	1	1	1	-	Total catch
26	2	3	5	2	3	Total catch
27	2	7	9	5	4	Total catch
28	18	31	49	33	15	Total catch
29	0	1	1	1	-	Total catch
30	3	3	6	6	-	Total catch
Total	25	48	73	50	22	
			Pacific cod			
15	3	1	4	-	4	Total catch
18	0	1	1	1	0	Total catch
26	1	-	1	0	1	Total catch
27	2	-	2	1	1	Total catch
Total	6	2	8	2	6	
			Pacific herring			
2	-	-	99	-	-	Random
26	-	-	76	-	-	Selected
27	-	-	97	-	-	Random
28	-	-	129	-	-	Total catch
Total	-	-	401	272	0	
			Walleye pollock			
5	8	8	16	-	-	Total catch
			Widow rockfish			
3	46	35	81	-	-	Total catch
			Bocaccio rockfish			
17	-	1	1	-	1	Total catch
18	1	3	4	4	-	Total catch
Total	1	4	5	4	1	

Table 12. Length frequency distribution of herring by set, August 10-22, 1985. (Midwater trawling denoted by MW; and bottom trawling by BT.)

Standard length (cm)	Cape Beale Spit	40-Mile Bank		
	Set no.	Set no.		
	2 (MW)	26 (BT)	27 (BT)	28 (BT)
15.0-15.2				
15.3-15.5				
15.6-15.8				
15.9-16.1				
16.2-16.4				
16.5-16.7				
16.8-17.0			1	
17.1-17.3			0	
17.4-17.6			0	1
17.7-17.9			0	0
18.0-18.2			1	2
18.3-18.5		1	0	2
18.6-18.8		0	1	4
18.9-19.1	10	0	1	2
19.2-19.4	13	1	2	6
19.5-19.7	10	1	1	6
19.8-20.0	12	2	3	5
20.1-20.3	9	2	5	9
20.4-20.6	16	4	6	6
20.7-20.9	7	5	5	10
21.0-21.2	6	3	10	17
21.3-21.5	6	9	7	10
21.6-21.8	3	8	9	6
21.9-22.1	1	5	8	8
22.2-22.4	1	12	8	4
22.5-22.7	2	3	8	2
22.8-23.0	2	6	6	11
23.1-23.3	0	4	3	4
23.4-23.6	1	3	3	5
23.7-23.9		3	1	3
24.0+		4	8	6
Total	99	76	97	129

Table 13. Herring age composition and mean length (standard) at age. Fish collected on La Pérouse Bank by F/V EASTWARD HO, August 10-22, 1985.

Location	Set no.	Age										
		0+	1+	2+	3+	4+	5+	6+	7+	8+	10+	Unknown
Cape Beale Spit	2											
No. fish		0	0	19	31	12	2	2	0	1	-	33
% at age		-	-	28.3	46.3	17.9	3.0	3.0	-	1.5	-	-
$\bar{x}$ length (cm)		-	-	19.45	20.25	21.30	21.50	22.80	-	22.60	-	20.19
$S_{\bar{x}}$ length		-	-	4.3	7.3	8.3	3.0	-	-	-	-	8.9
40-Mile Bank	26											
No. fish		0	0	1	15	12	6	6	1	3	1	17
% at age		-	-	2.2	33.3	26.7	13.3	13.3	2.2	6.7	2.2	-
$\bar{x}$ length (cm)		-	-	18.30	20.85	21.88	22.72	22.80	22.90	23.97	22.00	21.68
$S_{\bar{x}}$ length		-	-	-	6.6	7.1	4.4	9.1	-	0.5	-	11.1
40-Mile Bank	27											
No. fish		0	1	2	10	12	4	4	4	1	-	7
% at age		-	2.6	5.2	26.3	31.6	10.5	10.5	10.5	2.6	-	-
$\bar{x}$ length (cm)		-	16.90	19.05	20.33	21.42	22.28	22.20	23.00	23.50	-	22.17
$S_{\bar{x}}$ length		-	-	4.5	2.7	2.5	1.6	1.2	2.4	-	-	5.8
40-Mile Bank	28											
No. fish		0	0	5	13	9	4	4	0	2	-	28
% at age		-	-	13.5	35.1	24.3	10.8	10.8	-	5.4	-	-
$\bar{x}$ length (cm)		-	-	18.90	20.24	21.58	22.80	23.05	-	23.55	-	20.86
$S_{\bar{x}}$ length		-	-	4.5	2.4	1.8	7.0	3.5	-	1.1	-	2.8

Table 14. Pacific herring stomach contents. F/V EASTWARD HO, August 14, 1986 - Set 2.

	Size category (cm)		
	17.0-19.0	19.1-21.0	>21.1
Number examined	8	75	18
Number everted	0	0	0
Number empty	6	56	12
Number with contents	2	19	6
Diet - weight	(g, wet)	(g, wet)	(g, wet)
Euphausiid	0.6	27.5	18.8
Unidentified	0	1.0	0
Total	0.6	28.5	18.8

Table 15. Pacific herring stomach contents. F/V EASTWARD HO, August 20, 1986 - Set 26.

	Size category (cm)		
	17.0-19.0	19.1-21.0	>21.1
Number examined	1	13	48
Number everted	0	0	0
Number empty	0	0	4
Number with contents	1	13	44
Diet - weight	(g, wet)	(g, wet)	(g, wet)
Euphausiid	2.2	34.4	137.6
Total	2.2	34.4	137.6

Table 16. Pacific herring stomach contents. F/V EASTWARD HO, August 20, 1986 - Set 27.

	Size category (cm)					
	17.0-19.0		19.1-21.0		>21.1	
Number examined	1	0	14	4	29	11
Number everted	0	0	0	0	0	0
Number empty	0	0	2	0	5	2
Number with contents	1	0	12	4	24	9
Diet	g	cc	g	cc	g	cc
Euphausiid	1.4	0	30.4	10.5	75.6	29.5
Mean			2.5	2.6	3.2	3.3
Total	1.4	0	30.4	10.5	75.6	29.5

Table 17. Pacific herring stomach contents. F/V EASTWARD HO, August 20, 1986 - Set 28.

	Size category (cm)		
	17.0-19.0	19.1-21.0	>21.1
Number examined	6	30	29
Number everted	0	0	0
Number empty	0	7	6
Number with contents	6	23	23
Diet - weight	(g, wet)	(g, wet)	(g, wet)
Euphausiid	35.0	83.4	82.1
Total	35.0	83.4	82.1

Table 18. Other species sampled stomach contents. F/V EASTWARD HO, August 10-22, 1985.

Lingcod	
Number examined	50
Number empty	23
Diet - volume (cc)	(cc)
Pacific herring	986 (13)[a]
Fish remains (unid.)	109
Pacific saury	30
Total	1125
Pacific cod	
Number examined	2
Number empty	1
Diet - volume (cc)	(cc)
Pleuronectidae	15
Fish remains (unid.)	10
Zoarcidae	10
Pebbles	5
Total	40
Bocaccio rockfish	
Number examined	4
Number empty	4

[a]Brackets indicate total number of herring which were deemed measurable. Measurable herring are as follows: 19, 2 @ 20, 3 @ 21, and 24 cm.

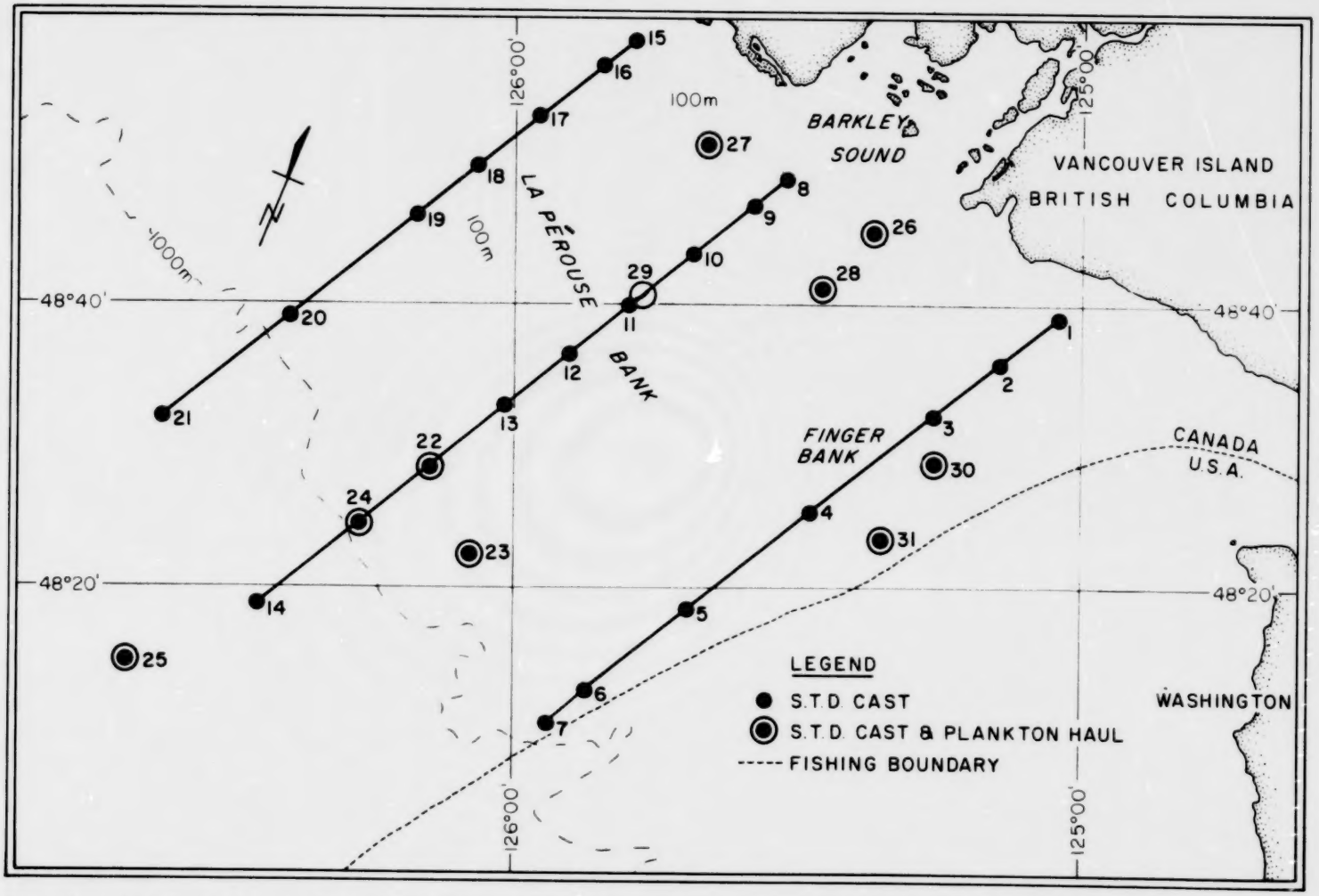

Fig. 1. Set locations of the STD casts and the vertical plankton hauls. F/V Eastward Ho, August 10-22, 1985.

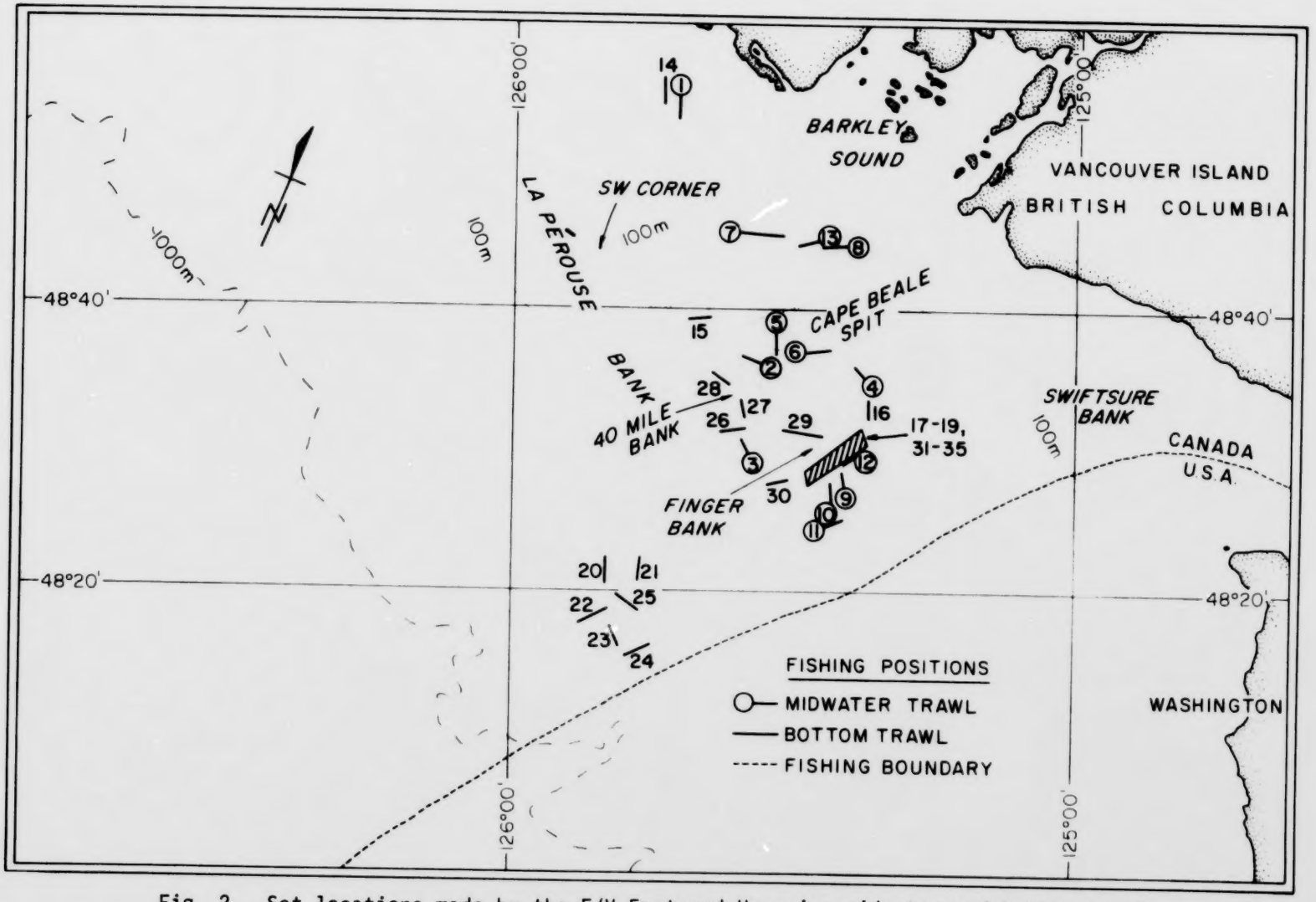

Fig. 2. Set locations made by the F/V Eastward Ho using midwater and bottom trawl gear. August 10-22, 1985.

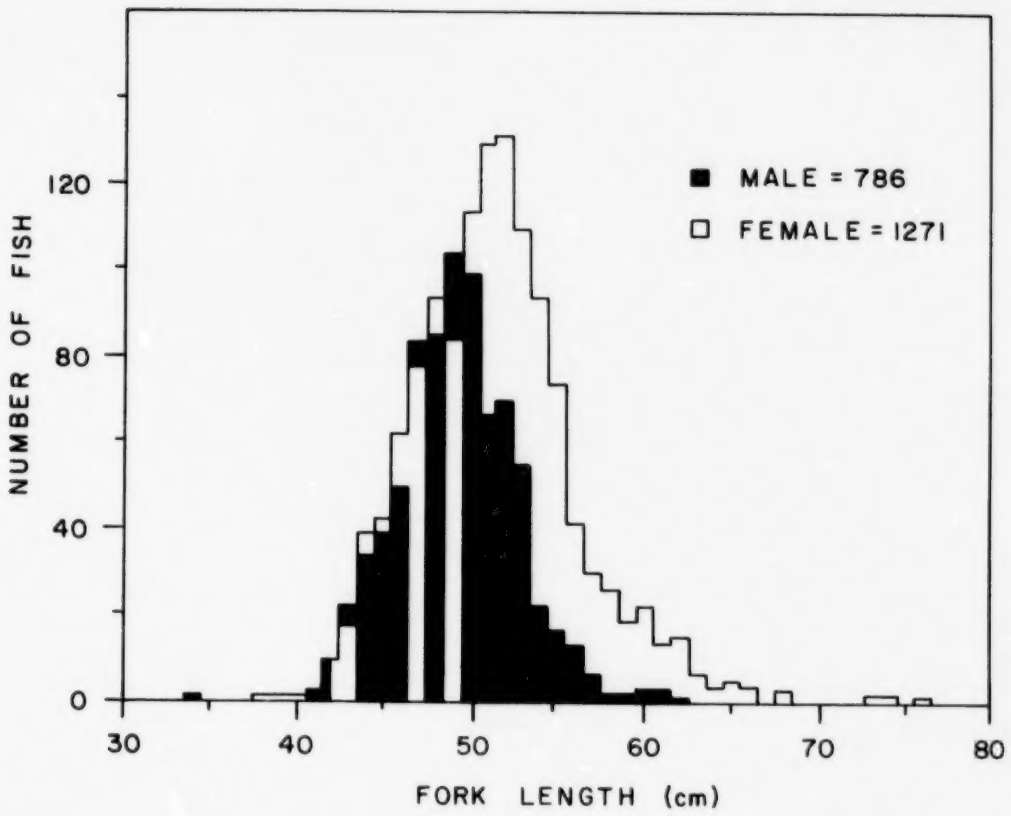

Fig. 3. Pacific hake length frequency by sex. F/V Eastward Ho, August 10-22, 1985.

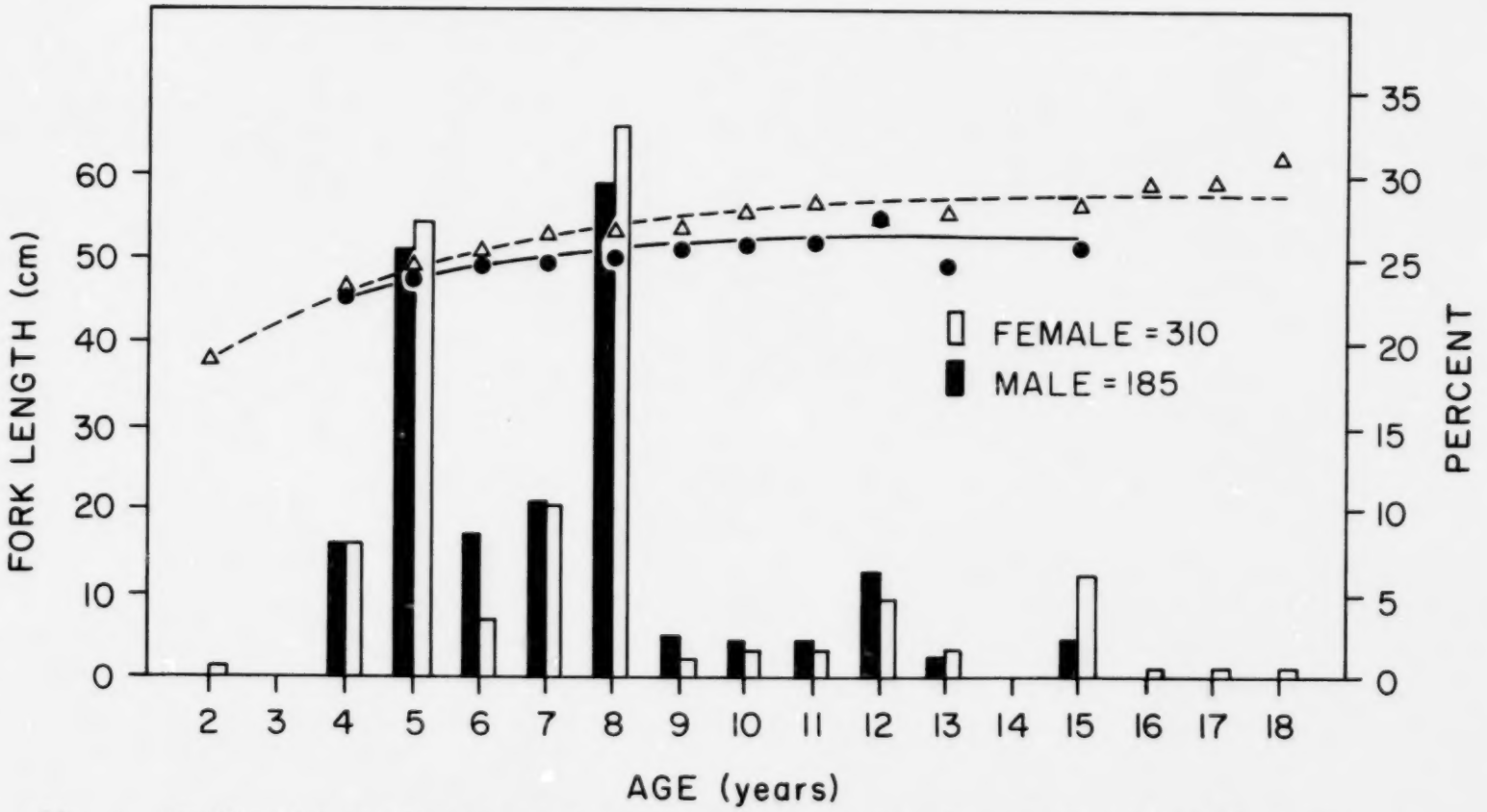

Fig. 4. Pacific hake age frequency and mean length at age plots (curves fitted by eye) by sex. F/V Eastward Ho, August 10-22, 1985.

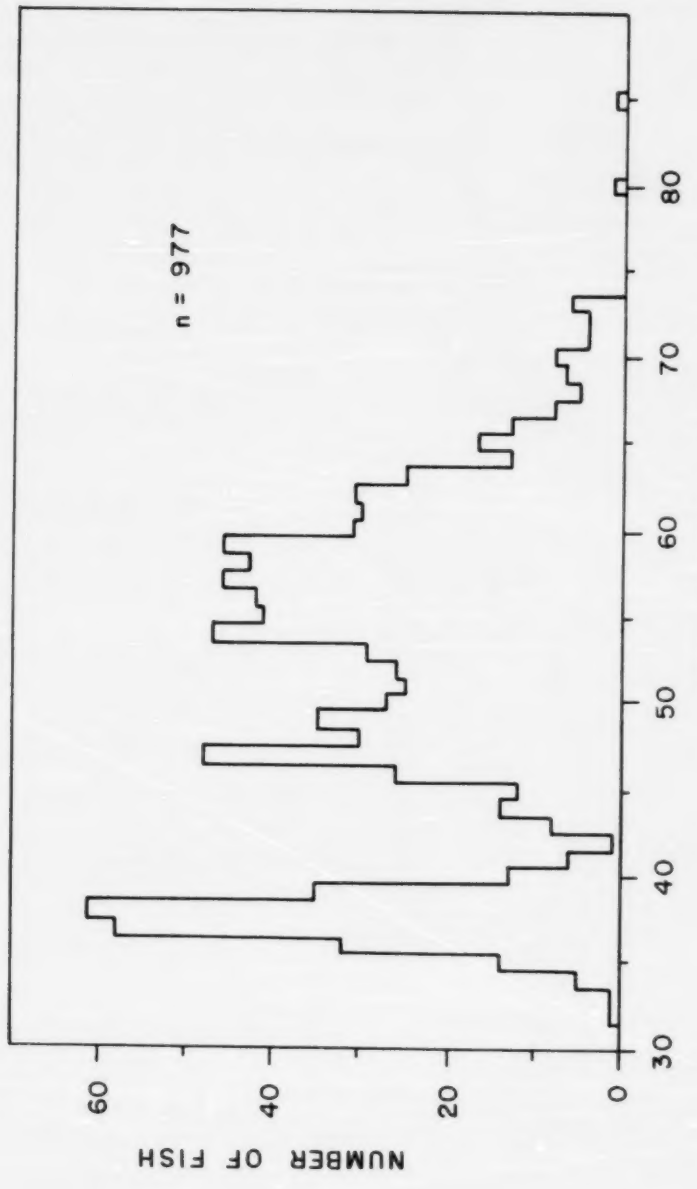

Fig. 5. Sablefish length frequency. F/V Eastward Ho, August 10-22, 1985.

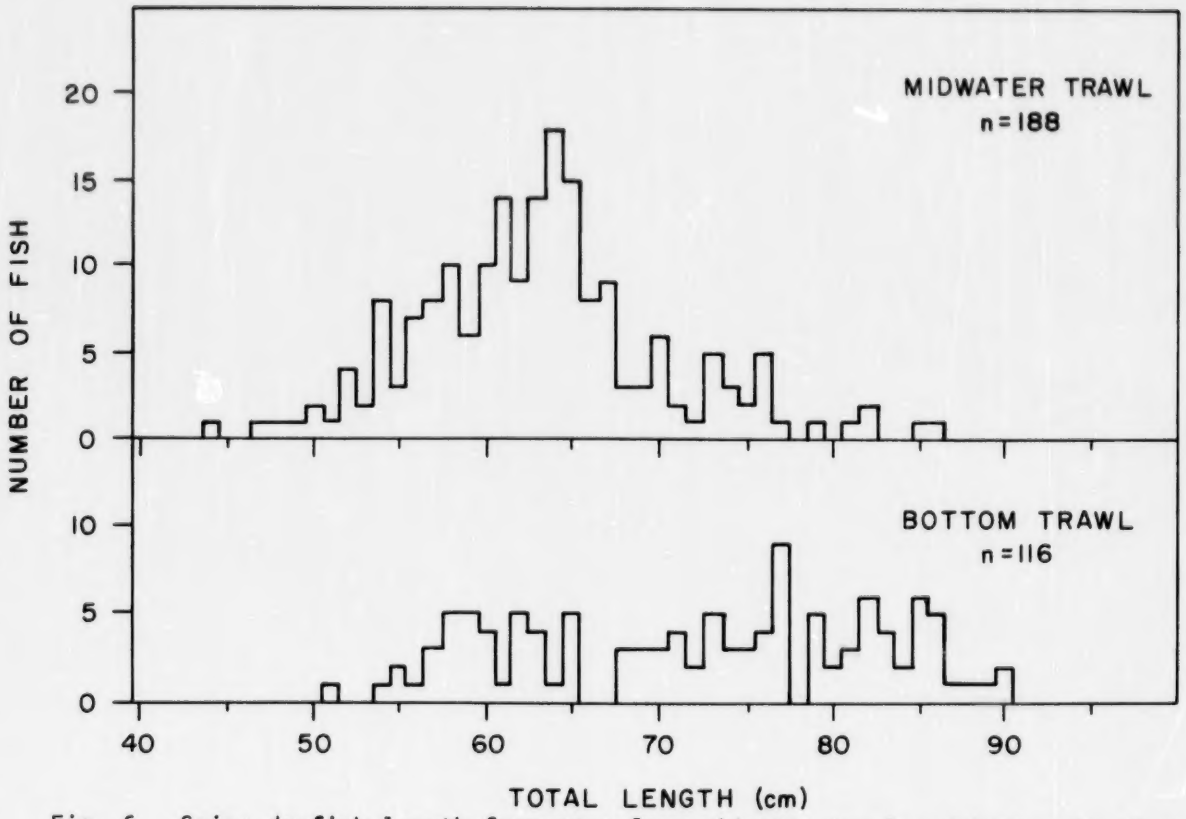

Fig. 6. Spiny dogfish length frequency from midwater trawl and bottom trawl catches. F/V Eastward Ho, August 10-22, 1985.

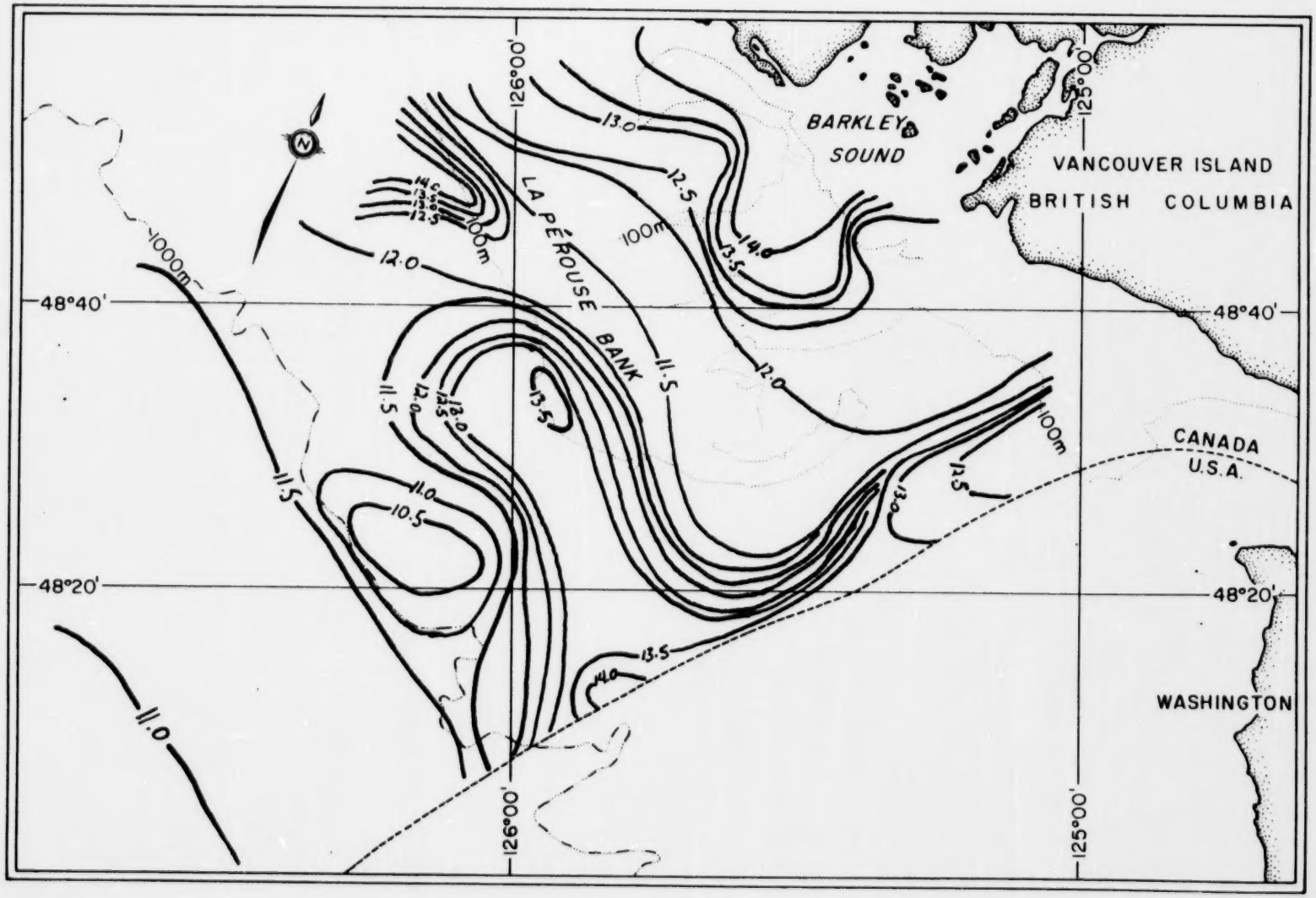

Fig. 7. Sea surface temperature (^{o}C) gradients using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

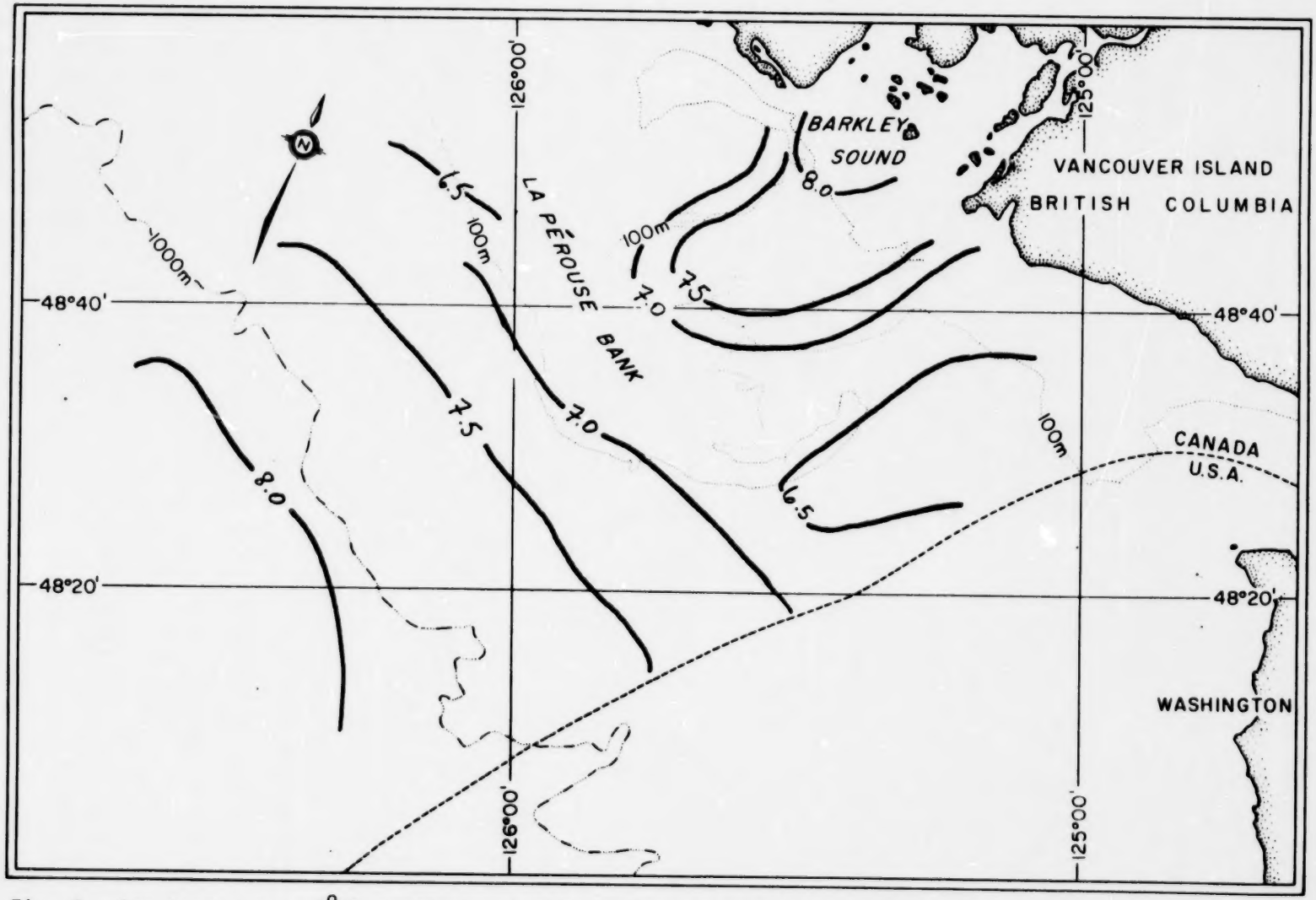

Fig. 8. Sea temperature (^{o}C) gradients at 100 m using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

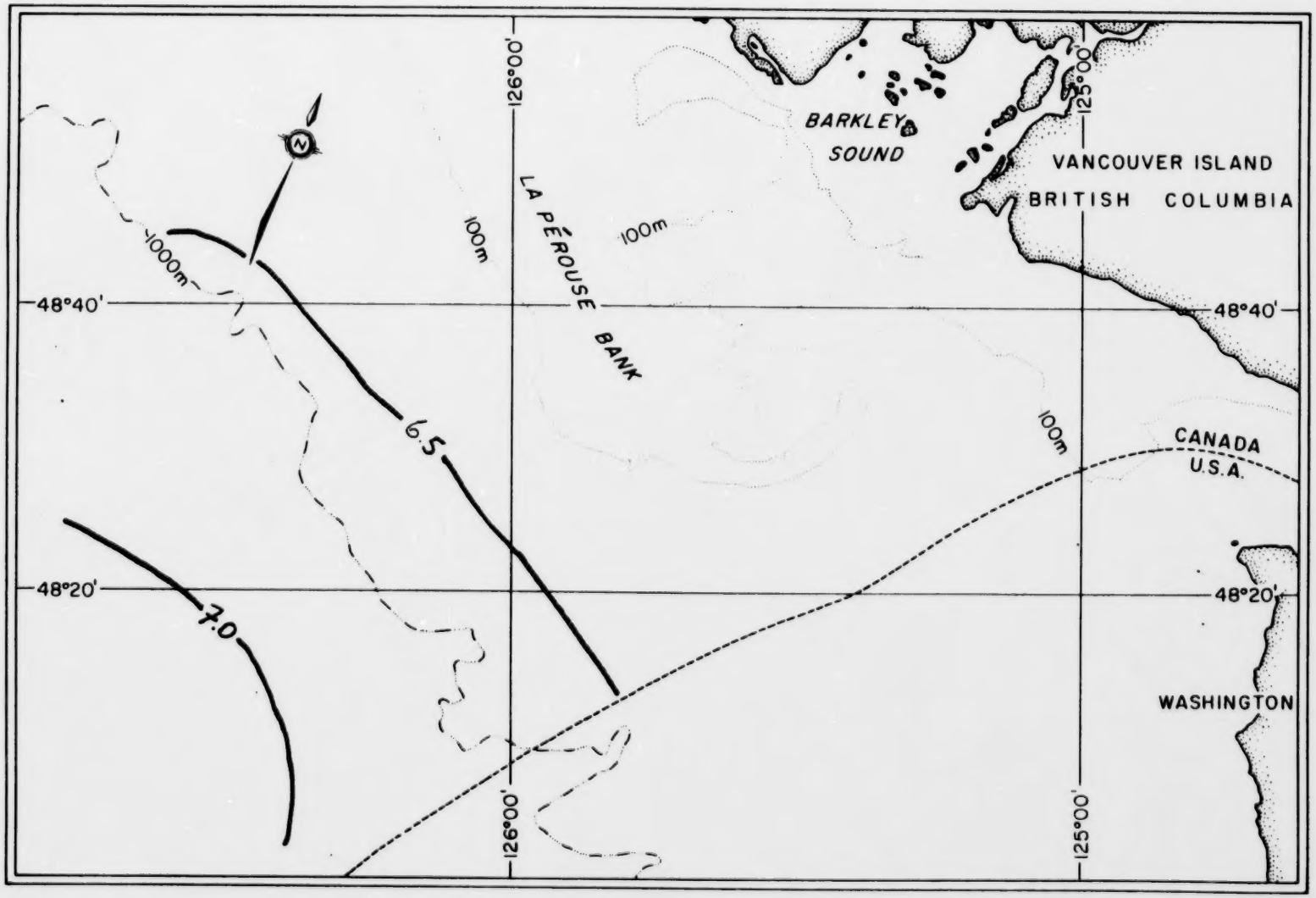

Fig. 9. Sea temperature (^{o}C) gradients at 200 m using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

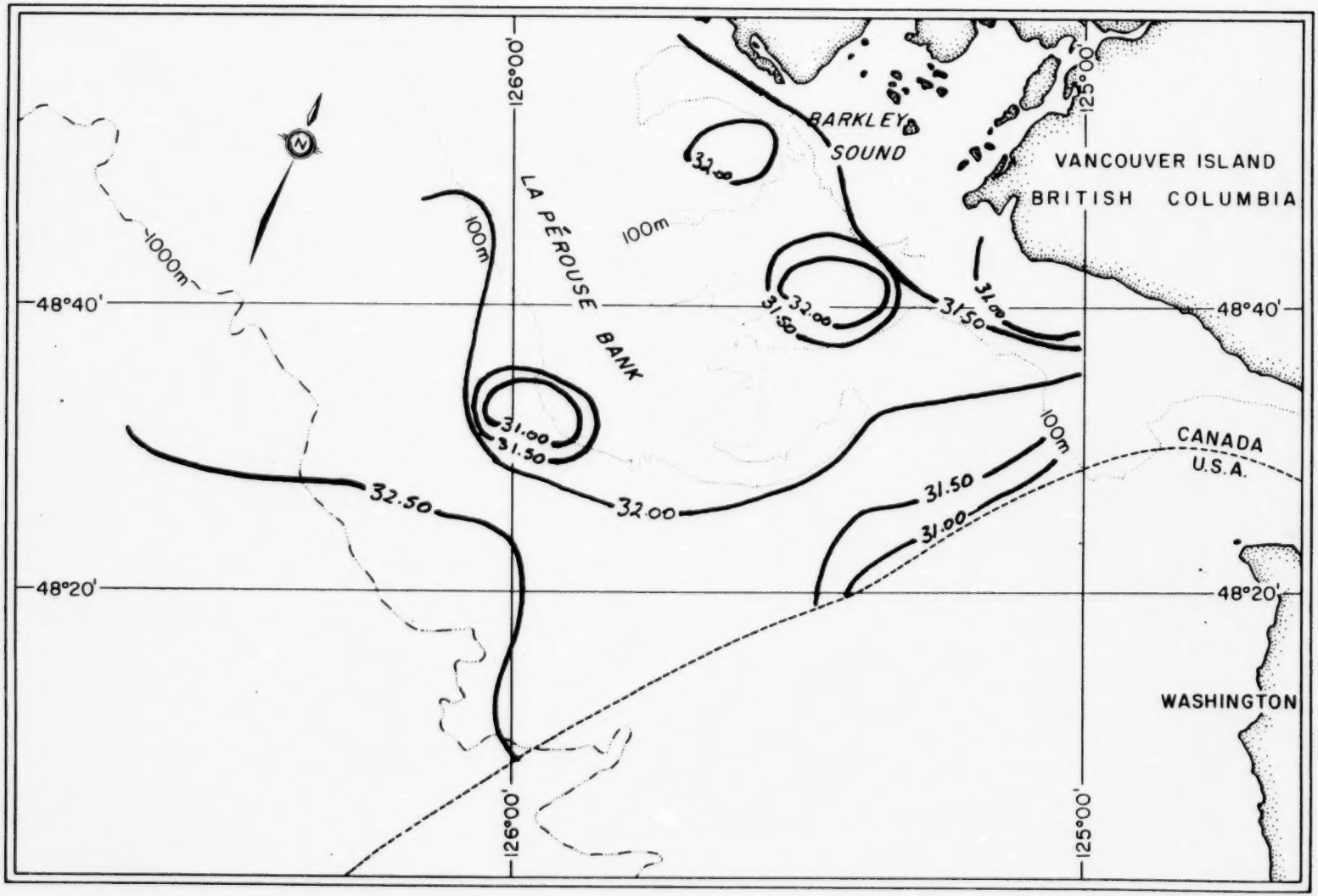

Fig. 10. Surface salinity ($^{o}/_{oo}$) gradients using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

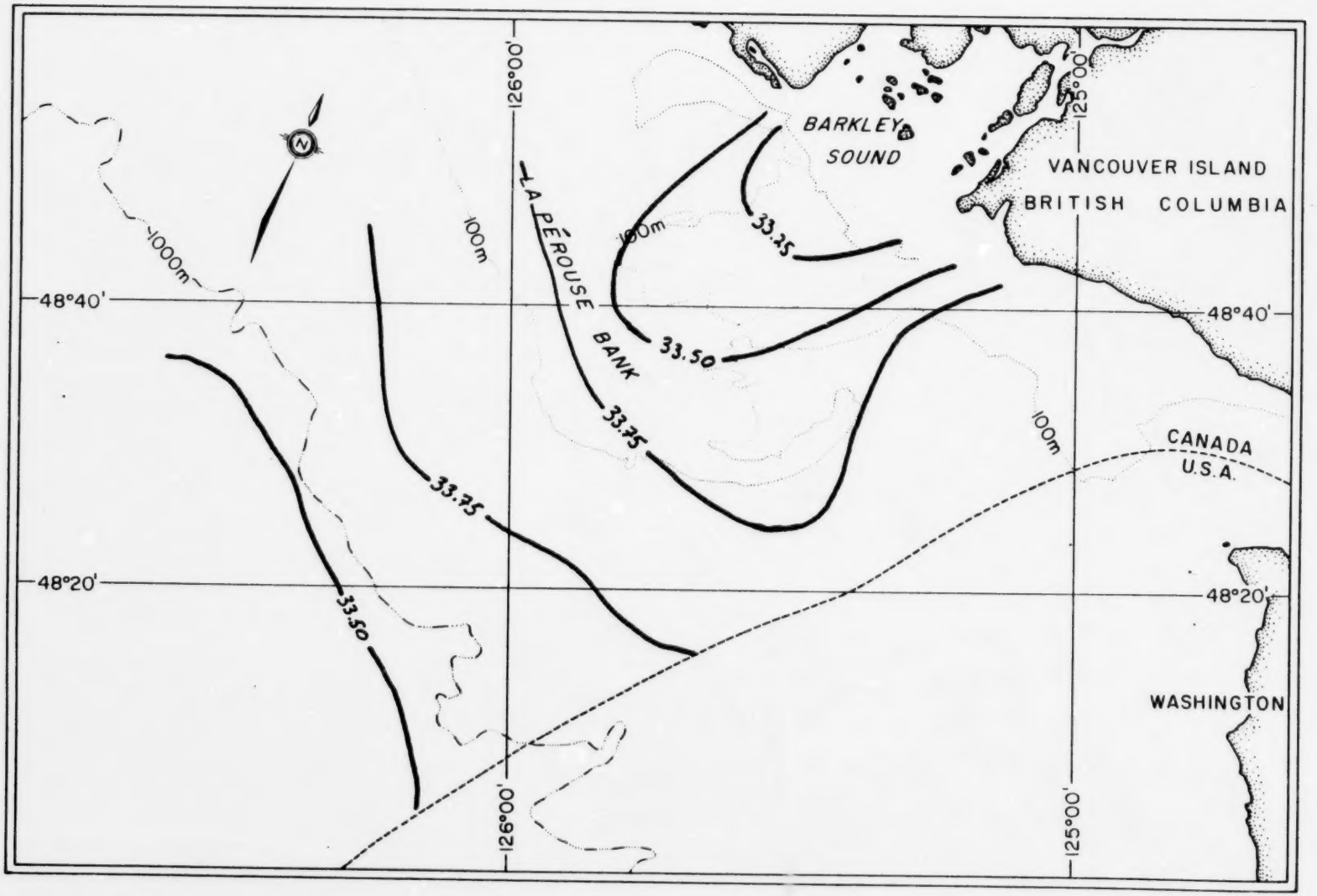

Fig. 11. Salinity ($^{o}/_{oo}$) gradients at 100 m using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

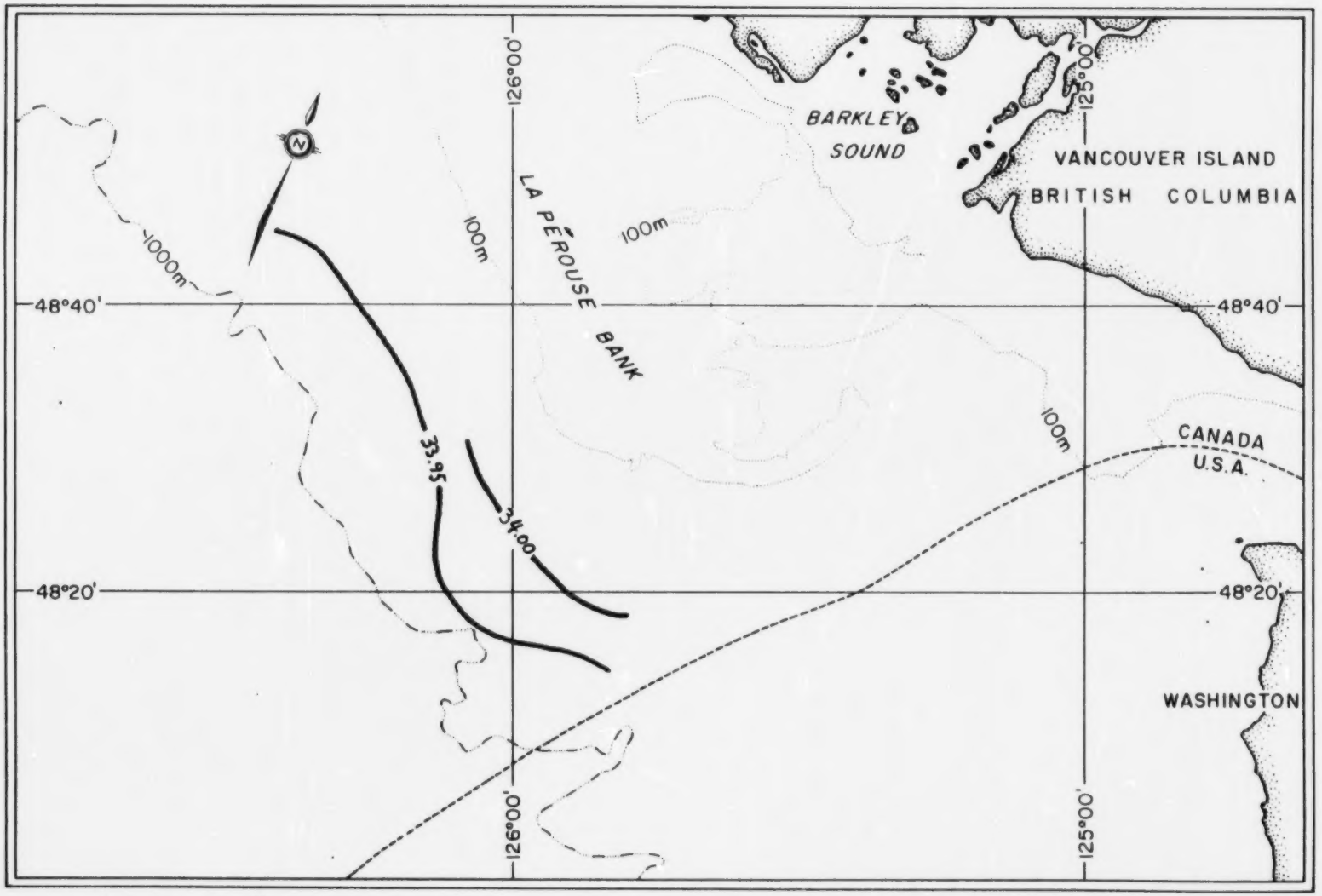

Fig. 12. Salinity ($^{o}/_{oo}$) gradients at 200 m using the STD-12 aboard the F/V Eastward Ho, August 10-22, 1985.

Pages 50 through pages 159 do not appear in paper, but appear in microfiche form at the back of this report.